Conversion Equations for Use in Section 403 Rulemaking

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EXECUTIVE SUMMARY

1. WHAT DOES THIS REPORT SAY?

This report presents equations used to carry out various conversions between wipe lead loading and vacuum lead loading, based on two different vacuum samplers, the Blue Nozzle vacuum (BN) used in the HUD National Survey, and the modified HVS3 vacuum used in the Baltimore Repair and Maintenance Study. The modified HVS3 vacuum will be referred to as the BRM vacuum for the remainder of this report.

Two sets of equations are described using the BN vacuum sampler: 1) for converting a BN lead loading to a wipe lead loading, 2) for converting a wipe lead loading to a BN lead loading. Each set contains a separate equation for samples collected from uncarpeted floors, window sills, and window wells. For the BN to wipe conversions on uncarpeted floors, a separate equation is provided for each of three house age groups in the HUD National Survey data.

The following equations were developed for converting a BN lead loading (µg/ft²) to a wipe lead loading (µg/ft²):

Uncarpeted floors:

Homes Built Prior to 1940: $\text{Wipe} = 5.66\ \text{BN}^{0.809}$

Homes Built 1940-1959: $\text{Wipe} = 4.78\ \text{BN}^{0.800}$

Homes Built 1960-1979: $\text{Wipe} = 4.03\ \text{BN}^{0.707}$

Window sills: $\text{Wipe} = 2.95\ \text{BN}^{1.18}$

Window wells: $\text{Wipe} = 5.71\ \text{BN}^{0.864}$

Thus, a BN lead loading of 100 µg/ft² on an uncarpeted floor, in homes built before 1940, would be converted to a wipe lead loading of 235 µg/ft², by applying the first of these equations. It has an approximate 95% confidence interval of 160 to 344 µg/ft². The 95% prediction interval is 31 to 1799 µg/ft². The confidence interval contains, with 95% probability, the average wipe lead loading associated with measured BN lead loadings of 100 µg/ft^2. The prediction interval contains, with 95% probability, 95 percent of individual future wipe measurements observed in the immediate vicinity of a BN lead loading of 100 µg/ft^2. Prediction intervals are wider because they incorporate the inherent variability in the dependent variable, whereas confidence intervals do not.

The following equations were developed for converting a wipe lead loading (µg/ft^2) to a BN lead loading (µg/ft^2):

Uncarpeted floors: $\text{BN} = 0.185\ \text{Wipe}^{0.931}$

Window sills: $BN = 0.955\ Wipe^{0.583}$

Window wells: $BN = 4.91\ Wipe^{0.449}$

Applying the first of the above equations, for example, a wipe lead loading of 100 µg/ft^2 on an uncarpeted floor would be converted to a BN lead loading of 13.5 µg/ft^2. It has an approximate 95% confidence interval of 9.47 to 19.0 µg/ft^2. The 95% prediction interval is 1.912 to 94.3 µg/ft^2.

For samples collected with the BRM vacuum sampler, from uncarpeted floors, carpeted floors, window sills, and window wells, the following equations were developed for converting a BRM lead loading (µg/ft²) to a wipe lead loading (µg/ft²):

Uncarpeted floors: $Wipe = 8.34\ BRM^{0.371}$

Carpeted floors: $Wipe = 3.01\ BRM^{0.227}$

Window sills: $Wipe = 14.8\ BRM^{0.453}$

Window wells: $Wipe = 13.9\ BRM^{0.630}$

For example, a BRM lead loading of 100 µg/ft² on an uncarpeted floor would be converted to a wipe lead loading of 46.0 µg/ft² by applying the first equation. An approximate 95% confidence interval for this prediction is 40.5 to 52.3 µg/ft². The 95% prediction interval of the wipe loadings associated with a BRM loading of 100 µg/ft² is 5.9 to 262 µg/ft².

2. WHY WERE THESE EQUATIONS DEVELOPED?

These conversion equations were developed for reasons related to the determination of standards required by the Residential Lead-Based Paint Hazard Reduction Act of 1992 (Title X), referred to as the Section 403 standards. It is likely that the Section 403 standards for dust lead will be expressed as a measured lead loading collected by a dust wipe sample. In considering different options for this standard, it is important to evaluate the number of homes that would be affected by the different options. The HUD National Survey of pre-1980 housing (the only national survey of dust lead levels) is the best source for making this assessment [1], [2], [3]. However, the BN vacuum was used in the National Survey to collect dust samples. Therefore, in order to use this data appropriately, it was necessary to convert the raw BN lead loading data to wipe lead loadings. Also, since the Baltimore Repair and Maintenance study dust samples were collected using a BRM vacuum, a conversion to a wipe lead loading was necessary in order for this data to be applicable to Section 403 analyses, such as sensitivity/specificity analyses and prevalence statistics.

3. HOW LARGE IS THE UNCERTAINTY ASSOCIATED WITH THESE CONVERSION EQUATIONS?

There is a considerable degree of uncertainty in the conversion equations based on BN vacuum samples. For the BN vacuum to wipe conversion, there is relatively little data. For example, on uncarpeted floors, one field study produced six pairs of side-by-side wipe and vacuum measures, another produced seven pairs, and a third produced 24 pairs. A larger amount of data was available to develop the conversion equations based on BRM vacuum samples. The Rochester Lead-in-Dust study alone provided over 350 BRM and wipe pairs on each housing component. Although this large amount of data allows fairly

accurate characterization of the relationship between the average wipe lead loading and an observed BRM lead loading, the inherent variability in wipe measures makes it important to recognize the wide range of plausible wipe lead loadings that could be associated with any observed BRM lead loading.

4. HOW WILL THESE CONVERSION EQUATIONS BE USED?

The BN to wipe conversion equations will be used to convert the BN dust-lead loadings measured in the National Survey to equivalent lead loadings for wipe samples. The transformed lead loadings will then be used to estimate the numbers and percentages of houses that would be affected for various options for defining dust-lead standards.

Similarly, the BRM to wipe conversion equations will be used to transform the BRM vacuum lead loadings in the Baltimore Repair and Maintenance study to equivalent wipe lead loadings for use in estimating prevalence statistics and in completing a sensitivity/specificity analysis which relates the incidence of elevated children's blood-lead levels to wipe lead loadings.

The wipe to BN conversion equations will be used in two ways for the Section 403 risk assessment. First, one window sill dust sample and one window well dust sample were collected via the wipe method in the HUD National Survey. Because the vast majority of samples were collected via the BN method, it was decided that these two samples should be converted to appropriate BN loadings for consistency. Second, two models were used to predict blood-lead levels: the IEUBK model and an empirical regression model. The empirical model uses as an input dust-lead levels measured by the BN sampler. Therefore, no conversion of the HUD National Survey data is necessary when using the empirical model to predict blood-lead levels from pre-intervention environmental-lead levels, or from post-intervention environmental-lead levels in homes where there is no expected intervention. However, in houses expected to undergo an intervention because dust- or soil-lead levels exceed options for standards, the post-intervention dust-lead loadings that are assigned in the analysis were estimated based on wipe data. These post-intervention estimates will be converted to BN lead loadings to be used as input to the empirical model.

The conversion equations presented in this report were developed for specific applications. The conversion of Blue Nozzle vacuum lead loading to wipe lead loading was developed for use with the HUD National Survey. The conversion of BRM vacuum lead loading to wipe lead loading was developed for use with the Baltimore Repair and Maintenance Study. The conversion of wipe lead loading to BN lead loading was developed primarily for converting estimated post-intervention wipe lead loadings to "equivalent" BN estimates. If the conversion equations developed in this report are used for other applications, the underlying assumptions for the statistical techniques used to derive the equations need to be confirmed for the new application.